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Synopsis

"Design and development of observer based control strategies for linear and nonlinear systems and its remote monitoring through IoT"

Ph.D. Work plan

Submitted to

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Submitted by:

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1. Abstract of proposed work/problem:-

In this work of PhD we are focusing on making some control strategy as robust using various techniques added to it we are also focusing on development of IoT technology to any process plant for analysis of data. The basic concept of Industry 4.0 will implant on this work for only monitoring purpose. We are trying to control any system with robust controller and, collect data from same system and monitor the results on cloud servers. Observer based techniques is an alternative for classical PID which is an attractive choice for practitioners and promises good robustness against parameter variations. A necessary modification for control strategy to increase the robustness will added into it with practical validation on some systems.

2. Introduction (Origin of research problem):-

In the recent era, there has been lots of work published on Active disturbance rejection control area for developing control strategies of any process. No doubt most of the research is going for making ADRC robust by different ways like using some techniques of sliding+ADRC, H∞+ADRC, Neural+ADRC, Fuzzy+ADRC etc. as a robust controller. This technique of doing mixing some strategies into ADRC or any other controller can be said as Hybrid controller. Of course ADRC technique depends on the system also, it means multiple input multiple output, but by changing the conditions of process it again a challenging task for controlling same thing. In this research we are trying to make a robust controller with the development of Internet of thing on plant for analyzing and monitoring data from processes.

3. Review of Literature and development in the subject (Previous work done in the relevant area):-

Many contributions have been made in the disturbance estimators over the past few years [3], which include disturbance observer, perturbation observer, unknown input observer and extended state observer. Disturbance-observer-based control (DOBC) and related methods have been researched and applied in various industrial sectors in the last four decades [12]. Extended state observer (ESO) which is a part of ADRC is becoming popular among control practitioners. ESO was designed to remove the need of a modeled plant by estimating and rejecting un-modeled plant dynamics.

A majority of the earlier work has been published by the Chinese research community since late 90's. Han being a major contributor and inspiration has combined the tools available into a structure that is known as ADRC. As proposed by Han [8], using nonlinear controller, the given process dynamics can be reduced to the canonical form of chain of integrators. The residue part of plant that is different from the canonical form if treated as total disturbance, which in turn is estimated and compensated by use of extended state observer. Tracking differentiator which originally is introduced in Han's work, is rarely used in the following years. It may be useful for the design of control law under the new modification proposed in this work. Originally ADRC involved a nonlinear controller [8], alternatively to make controller easy to implement and tune, a linear form of ADRC was introduced [1, 5]. Other modification may be introduced to make the controller more robust by using sliding, H infinity controller etc.

In recent years, the theoretical research has been gradually set in motion, targeting first various components of ADRC, such as the tracking differentiator, extended state observer, eventually arriving at, finally, and the property of the entire ADRC-based closed loop system.

The application of this ADRC is involved in large spectrum of process are like motion control, speed control of induction motor and permanent-magnet synchronous motor [15, 16, 17, 18], attitude tracking of rigid spacecraft, flight control [19, 20, 21], ADRC has been also applied to process control applications such as boiler-turbine-generator [10], distillation column [22], CSTR [13], coupled tanks [14] and water supply system [7].

An automatic disturbance rejection control (ADRC)-based model predictive torque control (MPTC) strategy is developed for permanent magnet synchronous motors (PMSMs) fed by three-phase four-switch inverters [23]. To overcome the delay, the extended state observer (ESO) in ADRC is modified to form a predictive ADRC, leading to significant improvements in the transient response and stability characteristics [24]. In some situations ADRC+H∞ controller used for removing uncertainties and making it robust [25]. The compound control of active-disturbance-rejection control (ADRC) with sliding mode is proposed to improve the performance of the closed-loop system and deal with the constraint condition problem of a surface ship [26]. [27] Paper is based on the classic flight control and the active-disturbance-rejection control principle, and uses the method of ADRC which based on RBF neural network. On the basis of analyzing the mathematic model of the permanent magnet synchronous motor (PMSM), a novel approach to PMSM servo system using fuzzy active disturbance rejection controller (ADRC) is explained in [28].

Though ADRC is recognized as a model-free controller, it requires a rough estimate of plant dynamics, on which the structure of ADRC depends. A method to estimate the parameter is given in [4] which is too complex and not much effective in practical scenario. The required estimate of process dynamics can be obtained by using open loop step response test.

Nowadays, there is a huge research in control and automation area using Internet of Things (IoT), where information is accumulated and processed to handle the machines relied on the analysis result [6]. Nowadays, as sensing, actuation, communication, and control become even more sophisticated and ubiquitous, there is a significant overlap in these communities, sometimes from slightly different perspectives [9].

There have been great advances in industrial Internet of Things (IIoT) and its related domains, such as industrial wireless networks (IWNs), big data, and cloud computing. These emerging technologies will bring great opportunities for promoting industrial upgrades and even allow the introduction of the fourth industrial revolution, namely, Industry 4.0. In the context of Industry 4.0, all kinds of intelligent equipment (e.g., industrial robots) supported by wired or wireless networks are widely adopted, and both real-time and delayed signals coexist. Therefore, based on the advancement of software defined networks technology, we propose a new concept for industrial environments by introducing software-defined IIoT in order to make the network more flexible [11].

Generally the applications of ADRC appears less in process control than in motion control. To demonstrate the validation of work some system will consider as a case study. The considered system suffers from measurement noise, external disturbances and uncertain dynamics. The inspiration behind this work is to demonstrate how simple and efficient it can be to design a model-free controller, which is robust against parameter variations and disturbances. It has been used, in very limited applications in process industries, as a replacement for PID control.

4. Objectives of Research/ Proposed Hypothesis:-

(a) To designing a gain factor for changes in ESO states to get robust and good performance along with practical validation on Internet of Things (IOT) either by OPC technique on PLC, DCS or by arduino or any other wireless sensors.

(b) To investigate various aspects of existing active disturbance rejection controller for their limitations and modify them suitably to use them for control applications in an efficient manner.

(c) To develop some new modification for non-linear ADRC or required changes in linear ADRC by variation of pole zero placement method.

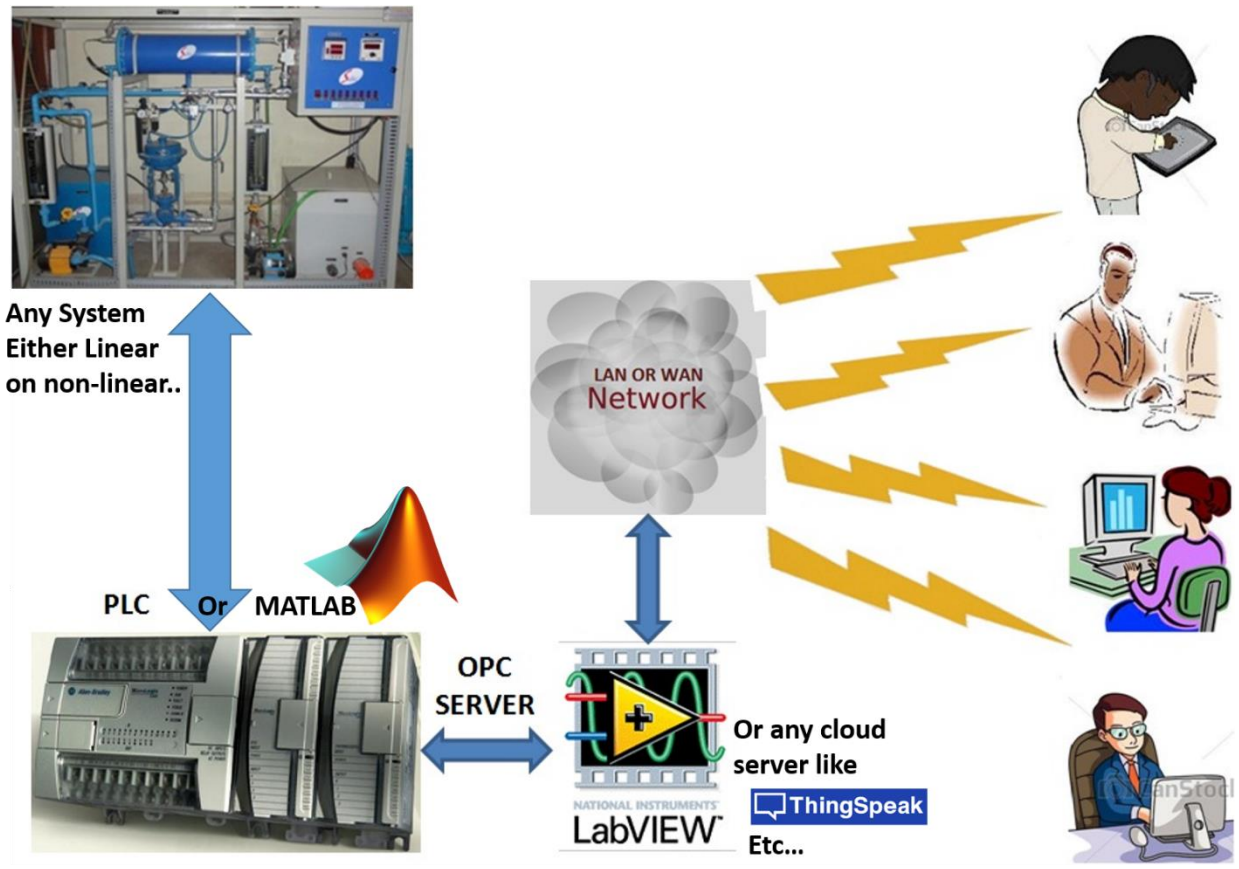
(d) To investigate some hybrid controller, which can be a fusion of ADRC and other robust controller like sliding mode, H∞ etc. controllers.

(e) To investigate controller results on some process, and modification with same process control strategy for more robust results.

(f) To investigate the coupling effect of square multivariable system using existing control technique for its limitations and modify them using disturbance decoupling strategy.

5. Methodology to be adapted:-

A various control strategy is to be studied and flaws and merits in them are identified based on which any feasible, possible modification that is implemented on it to make it more robust compared to existing ones. For example, hybrid combination with ADRC or design of some other robust control strategy which can be combined with Active Disturbance Rejection Control (ADRC).



6. Importance of study/ Society application (International/ National status / Significance): -

It is motivated by the ever increasing demands from industry that requires the control technology to move beyond PID, which has dominated the practice for over 80 years. Jingqing Han, is the originator for this technique. The way of dependence on mathematical models is totally changing after disturbance rejection technique. Everywhere in globe it is accepted. Those who are having problems to deal with mathematical models and external disturbances or uncertainty in dynamics of system, they are worshipped by this technique. So many industries are now using disturbance removal in there algorithms. Also there is new trending on IIOT which is industry 4.0 developing in market. It means making plant virtual with the help of internet. Every industry is now focusing on internet of things for easy accessibility and easy analysis of growth rate of industry.

7. Proposed work Plan/ Formulation and Structure of Study:-

Year-wise Plan of work and targets to be achieved

	Year I	Year II	Year III
First Six month	Literature survey, Problem study.	Case study on any process or develop new modifications in control strategies according to process	Validation on same process
Second Six month	Apply knowledge on available strategies or get know about errors in process variations.	Designing, modelling, Development	Report writing

8. Expected outcomes:-

Respective system should be work properly with design strategy with all parameter variations, it should be robust for all uncertain variation or any disturbance in system. Designing of industry based model remote monitoring for respective system with more modification as compare to robustness.

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